CLAIMS

Having thus described our invention, what we claim as new, and desire to secure by Letters Patent is:

1. A high aspect ratio, solid-metal filled via, comprising:

a semiconductor substrate having a high aspect ratio via defined therein, said via having a bottom and at least one sidewall;

a layer of an electrical insulator lining said via bottom and said at least one sidewall, wherein said insulator electrically isolates said via from said substrate;

a layer of an adhesion promoter lining said insulator;

a layer of a seed material lining said adhesion promoter; and

a solid metal rod filling said via.

2. The high aspect ratio, solid-metal filled via, according to claim 1, wherein said via opens to a major surface of said semiconductor substrate.

3. The high aspect ratio, solid-metal filled via, according to claim 2, wherein said major surface is lined with a stack comprising:

a layer of an electrical insulator continuous with said insulator layer lining said via;

a layer of an adhesion promoter continuous with said promoter layer lining said via; and

a layer of a seed material continuous with said seed layer lining said via.

4. The high aspect ratio, solid-metal filled via, according to claim 1, wherein said semiconductor substrate is selected from the group consisting of silicon, quartz, glass and high temperature polymer.

5. The high aspect ratio, solid-metal filled via, according to claim 1, wherein said insulator is selected from the group consisting of silicon nitride, silicon oxide, silicon oxynitride, and SiN/SiO_2 stack.

6. The high aspect ratio, solid-metal filled via, according to claim 1, wherein said adhesion promoter is selected from the group consisting of Ta, Cr, Ti, TaN, and TiN.

7. The high aspect ratio, solid-metal filled via, according to claim 1, wherein said seed is selected from the group consisting of tungsten and molybdenum.

8. The high aspect ratio, solid-metal filled via, according to claim 1, wherein said solid-metal filler is selected from the group consisting of tungsten, molybdenum, tantalum, and gold.

9. The high aspect ratio, solid-metal filled via, according to claim 5, wherein the thickness of said adhesion promoter layer is from about 100 nanometers to about 5 micro meters.

10. The high aspect ratio, solid-metal filled via, according to claim 6, wherein the thickness of said insulator layer is from about 10 nanometers to about 500 nanometers.

11. The high aspect ratio, solid-metal filled via, according to claim 7, wherein the thickness of said seed layer is from about 10 nanometers to about 500 nanometers.

12. The high aspect ratio, solid-metal filled via, according to claim 3, wherein said metal filler and said stack are planarized to said major surface of said substrate.

13. The high aspect ratio, solid-metal filled via, according to claim 1, wherein the aspect ratio of said via is from about 3:1 to about 10:1.

14. A method of fabricating a high aspect ratio, solid-metal filled via comprising:

providing a semiconductor substrate;

defining a high aspect ratio via in said substrate, wherein said via has a bottom and at least one sidewall;

lining said via bottom and said at least one sidewall with a layer of an electrical insulator, wherein said insulator electrically isolates said via from said substrate;

lining said insulator with a layer of an adhesion promoter;

lining said adhesion promoter with a layer of a seed material; and

filling said via with a solid metal.

15. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 14, wherein the aspect ratio of said via is from about 3:1 to about 10:1.

16. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 14, wherein said via opens to a major surface of said semiconductor substrate.

17. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 14, further comprising:

lining said major surface with a stack comprising:

a layer of an electrical insulator continuous with said insulator layer lining said via;

a layer of an adhesion promoter continuous with said promoter layer lining said via; and

a layer of a seed material continuous with said seed layer lining said via.

18. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 14, wherein said semiconductor substrate is selected from the group consisting of silicon, quartz, glass, and high temperature polymer.

19. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 14, wherein said insulator is selected from the group consisting of silicon nitride, silicon oxide, silicon oxynitride, and a SiN/SiO_2 stack.

20. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 14, wherein said adhesion promoter is selected from the group consisting of Ta, Cr, Ti, TaN, and TiN.

21. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 14, wherein said seed is selected from the group consisting of tungsten and molybdenum.

22. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 14, wherein said solid-metal filler is selected from the group consisting of tungsten, molybdenum, tantalum, and gold.

23. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 14, wherein filling with a solid metal comprises a thermally-activated chemical vapor deposition (CVD) process.

24. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 23, wherein said CVD comprises laser-assisted CVD (LCVD).

25. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 24, wherein said LCVD comprises a continuous-wave laser.

26. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 24, wherein said laser couples with a material selected from the group consisting of said seed and said adhesion promoter.

27. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 26, wherein said LCVD further comprises:

providing an ambient comprising at least one precursor gas and at least one reducing gas;

forming a nucleation site for a growth of metal by forming a focus of said laser on said coupling material on said bottom of at least one of said vias;

depositing metal at said nucleation site; and

continuing to deposit metal at a growing rate.

28. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 26, wherein said LCVD further comprises:

mounting said substrate on a three-axis mount; and

propagating the growth of a metal rod by moving said mount away from said focus at a rate substantially equal to said growing rate.

29. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 27, wherein said precursor gas is selected from the group consisting of WF_6, WCl_6, $W(CO)_6$, MoF_6, $MoCl_6$, and $Mo(CO)_6$.

30. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 29, wherein a preferred precursor gas is WF_6.

31. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 27, wherein said reducing gas is selected from the group consisting of hydrogen and silane.

32. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 27, wherein said focus is formed by directing said laser through a lens.

33. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 27, further comprising;

providing an array of vias;

providing an array of lenses such that a focus is formed in each of said vias; and

forming a metal rod in each of said vias.

34. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 27, further comprising;

providing an array of vias;

providing a mask having an array of voids defined therethrough, wherein said mask does not couple to said laser;

irradiating said array of vias through said mask; and

forming a metal rod in each of said vias.

35. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 27, further comprising;

providing an array of vias;

providing a reaction chamber to contain said mount, said array of vias, and said ambient;

providing a mask having an array of voids defined therethrough, wherein said mask is positioned outside said chamber;

irradiating said array of vias through said mask; and

forming a metal rod in each of said vias.

36. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 27, further comprising;

providing an array of vias;

providing a high pulse rate, laser microvia drill;

irradiating said array of vias using said microvia drill; and

forming a metal rod in each of said vias.

37. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 34, wherein said mask is a holographic phase mask.

38. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 24, wherein said LCVD comprises a pulsed laser.

39. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 17, further comprising:

polishing said via co-planar with said major surface by CMP.

40. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 39, further comprising:

removing said adhesion layer and said seed layer from said major surface by CMP.

41. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 33, further comprising:

polishing said array of vias co-planar with said major surface by CMP.

42. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 27, further comprising:

forming an array of vias in said substrate;

mounting said substrate in a reaction chamber having a laser-transparent window;

forming a laser focus in each via of said array, thereby forming a nucleation site in each of said vias; and

forming a rod by translating said mount in a direction parallel to the beam of said laser.

43. The method of fabricating a high aspect ratio, solid-metal filled via, according to claim 25, wherein

said laser radiates at a wavelength that couples with the rod metal; and TiN, and wherein

said laser does not couple to any of SiO_2, SiN, and Si.

44. A high aspect ratio, solid-metal filled through-via, comprising:

a semiconductor substrate having opposed major surfaces and a high aspect ratio via defined therethrough, wherein said via has at least one sidewall and opens to each of said major surfaces;

a layer of an electrical insulator lining said at least one sidewall, wherein said insulator electrically isolates said via from said substrate;

a layer of an adhesion promoter lining said insulator;

a layer of a seed material lining said adhesion promoter; and

a solid metal rod filling said via.